Wisconsin Geological
and Natural History Survey

I. C. 6264

APRIL, 1930

DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
SCOTT TURNER, DIRECTOR

INFORMATION CIRCULAR

ELECTRICAL BLASTING PRACTICE AT SOME COAL MINES IN THE STATE OF WASHINGTON

BY

S. H. ASH

Digitized by Google

I.C.6264.
April, 1930.

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

ELECTRICAL BLASTING PRACTICE AT SOME COAL MINES IN THE STATE OF WASHINGTON[1]

By S. H. Ash[2]

As part of the work done at the Washington coal mines during the year 1929, a study was made of the safety practices in and about the mines. Inasmuch as electrical blasting has made considerable headway it is interesting to note the manner in which it is done and the reasons why it was discarded at some of the mines.

Blasting is done at the mines in the State by means of capped fuse, electric blasting "caps," and in some instances by electric delay detonators. Black blasting powder with fuse is used at most of the open-light mines. The use of squibs was discontinued several years ago because the coal operators, without exception, recognized the dangers incidental to their use. Permissible explosive and dynamite are also used at some of the open-light mines. With the exception of some rock work and the driving of level work in gangways and air courses the explosive is detonated by means of capped fuse.

EXPLOSIVES USED

Permissible explosive is used exclusively for blasting coal at all coal mines classed as gassy, and for blasting rock at some mines; but at the majority of the mines 40 and 60 per cent dynamite is used in rock tunnels, of which there are many due to the crosscutting of the heavy dipping seams, and is also used in gangway driving through faults. For the purpose of detonating the explosive both fuse and "caps," and electric detonators are used. The discussion of this latter phase of blasting is the principal object of this paper.

The following table shows the production obtained under the different systems of blasting.

---

1 - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6264."

2 - Mining engineer, U. S. Bureau of Mines.

Digitized by Google

No. of mines	Kind of explosive	How exploded	Tonnage (net tons)	Percentage of tonnage	Persons employed underground
Open-light mines:					
24	Black blasting powder	Fuse	648,405	25.7	532
15	Permissible and dynamite[1]	Fuse and "Caps"	186,606	7.5	243
39			835,011	33.2	775
Closed-light mines:					
6	Permissible	Electric detonators	1,024,232	40.6	1,087
14	Permissible	Fuse and "caps"	660,167	26.2	770
20			1,684,399	66.8	1,857
59	The State[2]		2,519,410	100.0	2,632

1 - Not segregated, mostly permissible.
2 - State mine inspector's report, 1928.

OPEN AND CLOSED LIGHT MINES

It is seen that two-thirds of the coal produced in the State comes from mines classed as gassy and using closed lights; no mines classed as nongassy use closed lights. The use of open lights should be prohibited, if for no other reason than the danger from fires; the handling of black blasting powder where open lights are worn constitutes a serious hazard. Experiments performed by one of the large companies using open lights have proved that there is an actual saving in efficiency due to time saved from continually "tinkering" with carbide lamps. Permissible electric cap lamps give a steady uniform light, save time, and tend to reduce accidents due to rock falls.

One-fourth of the tonnage comes from open-light mines using black blasting powder. This explosive is used in mines working seams lying on dips ranging from zero to 16°. Mechanization is making rapid strides in these mines; and within the next year this coal, which is now practically all "blasted off the solid," will probably be cut by mining machines and transported by mechanical conveyors. In discussing this phase of the situation the writer learned that permissible explosive fired electrically would probably be used at the large mines to save time loss and danger from waiting for smoke to be carried away and waiting after missed shots.

There have been no accidents due to electric blasting during the past two years.

Digitized by Google

Fatal accidents due to blasting with fuse and "caps" have occurred at Washington mines, one during 1929. For this reason the State mine inspector has urged that electric blasting be adopted at all mines, if for no other reason than to prevent a recurrence of an accident caused by a missed shot. This hazard from fuse is especially great at the open-light mines, where the miners drill, load, and blast all of the shots.

In the closed-light mines the use of fuse and detonators for firing the permissible explosive is confined to the steeply dipping seams. Although but 26.2 per cent of the tonnage is produced in these mines the many dangerous factors such as gas and dust are sufficient reason for giving serious consideration to electric blasting. Several factors prevent the use of electric blasting. Owing to the nature of the walls the pitch workings are opened by narrow chutes varying from 4 to 10 feet in width. These must be heavily timbered. No practical mining machine has been developed that can be used in such narrow places on dips over 45°, with a result that practically all of the blasting is done "off the solid." In addition, competitive mines are located in the coking-coal areas, and due to the unusual friability of the coal no attempt is made to obtain coarse sizes. For this reason cutting or shearing of the coal is not considered to any degree. When a round is blasted the object to be attained is to make room for one timber set, or an advance of about 6 feet. Several shots are blasted at one time, and although the mining law is specific relative to the blasting of dependent shots, the opening shot is supposed to be blasted first, and the fuse is cut to space the time of firing. Herein lies the danger; if the cut shot fails to "pull" or exposes or leaves inadequate burden on the charge of explosive. The cut shot may also raise a cloud of dust into suspension and succeeding shots may ignite the coal dust.

BLASTING IN NARROW CHUTES

Blasting electrically off the solid one shot at a time, where the round consists of more than one hole, is neither practicable nor safe in the narrow chutes, because the miner would have to return to the face on pitches up to vertical to attach his lead wires. There is danger from falling material and to return to the face in the smoke would be extremely hazardous. Blasting, as a rule, is done at noon and at quitting time, although not usually at both times at the face of the chutes. The place is allowed to clear and the loose material released before the miner returns to the face. Lives have been lost when miners tried to return to the face too soon, due to falling material or to being overcome by smoke. At one gassy mine, because of the very bad walls, chutes over 6 feet in width could not be kept open for the lift being worked. The seam was gassy to such an extent that each shot liberated so much methane it was dangerous to blast for some time. Electric blasting, one shot at a time, was tried, but due to the fact that too many holes had to be drilled under adverse circumstances and considerable time was lost due to trimming the face and fixing up the lead wires, blasting was dispensed with altogether.

Under this system progress was so costly mining could not be done at a profit. It was finally decided to shorten the lift by driving a counter gangway above the active one. In driving such narrow chutes ventilation is carried from the last crosscut to the face by means of canvas brattice which has to be replaced after each blasting operation. The reason for driving such narrow chutes is the saving in first cost due to timbering.

Digitized by Google

The writer does not believe that driving narrow chutes is justified in the long run, except in very short lifts (up to 200 feet) and then only in a nongassy seam. Experience in the same mines and seams has proved that chutes 8 feet to 10 feet in width with a wooden brattice carried up the center are the most economical in the long run. The extra cost is more than offset when drawing the pillars. Even in the wider chutes, holes must be placed on the solid; blasting can be done electrically, and it would be much safer, as well as more practical, to blast all shots in the round simultaneously. There would not be any trouble in attaching the lead wires and the numerous dangers from falls of roof or coal, or from explosive fumes would be avoided.

BLASTING IN PITCHING SEAMS

In most instances the pitch workings do not work more than one shift. Undercutting the coal by hand or by post punchers, if possible, would be more efficient mining practice, because blasting could be done once each day at the close of the shift. The entire round could then be blasted electrically when the men are out of the mine,

It is a fact that the demand for coarse sizes of coal in the coking grades is greater than the supply. Further, the realization from lump-coal sales is 20 per cent greater than for the fines. The undercutting or shearing of the face is justifiable from this angle. Long lifts in seams requiring narrow chutes result in a loss of coal, extra dead work, and cost of timber that would be saved if shorter lifts were worked.

Some of the most disastrous explosions in the pitching seams have occurred at blasting time, and the writer believes that in the interest of safety changes in the system of mining are justifiable whereby approved blasting practice could be followed. At some of the mines fewer chutes could be driven on the full dip to be used as loading chutes and the coal extracted in panels with rooms driven on the strike. The coal could be cut by chain machines and the coal conveyed to the loading chutes in the same manner as is being done in the less steeply dipping seams. Ventilation would be easier, and there would be an increase in coarser sizes with a resultant higher sales realization.

LIGHTING SHOTS IN GASSY MINES

In gassy mines where fuse and detonators are used the shots are lighted by shot firers using punk or touch paper. In some instances the holes are inspected by the shot firers before loading. In others the holes are loaded by the miners before the shot firer reaches the place. The shots are all blasted when the men are still in the mine. In most instances the shot firers are certified men, but the mining law in the State of Washington has been construed to mean that shot firers are not required to be certified men; this construction is not in the best interests of safety. If there is any individual in whose hands lies not only the lives of many persons, if blasting is done in gassy mines when the men are in the mine, or in whose hands lies the responsibility of protecting the property under any circumstances, it is the shot firer. He should not only be a certified man, but he also

Digitized by Google

should be extremely conscientious, and possess a thorough knowledge of ventilation, gases, breaking ground, and the use of explosives.

During 1929 a fire occurred at one of the large closed-light mines where fuse and detonators were used. A hazardous situation not only resulted, but it cost considerable money and necessitated the sealing off of an important section of the mine, which was not recovered for some time. This was caused by the fuse, used for blasting, igniting some gas feeders. Incidents of this kind justify the adoption of electric blasting and of mining methods favorable to its application.

SOLID SHOTS

One definition of solid shooting is that a solid shot is one so drilled that any line drawn normal to the hole from the bottom of the hole fails to intersect a free face: this is not a good definition, and it should be qualified. Obviously, in a very wide place, as in a wide room or a longwall face, holes could be drilled to a considerable depth and still fill the requirement. Further, in drilling holes in a pillar block a line can be drawn normal to the bottom of a hole drilled normal to the free face from which the hole was driven and pass through two free faces, such as the sides of the pillar. To prevent the drilling of long holes under any circumstances the mining law states that "no hole shall be drilled more than six (6) feet in depth for the purpose of blasting except where mining machines are used holes may be drilled to the depth of the cut."[3]

ADVANTAGES OF ELECTRIC BLASTING

Probably the major reasons for adopting electric blasting is the elimination of the danger from missed shots and the time loss incidental to their occurrence. The State mining law has the following provision.[4] "No person shall return to a missed shot, if lighted with a squib, until twenty (20) minutes have elapsed from the time of lighting the same, or, if lighted with a fuse, until eight (8) hours have elapsed; and no person shall return to a missed shot when the firing is done by electricity unless the wires are disconnected from the battery."

It is encouraging to note that at the present time practically 41 per cent of the tonnage of the State is obtained at mines having electric blasting. This practice is confined to the largest mines in the state where the dips are from 5 to 30°. It is also noteworthy that in addition to adopting this progressive safety measure 5 of these mines are rock-dusting all accessible parts.

The closed-light mines where electric blasting is done can be divided into two groups, one of which employs shot firers, who are certified men, and the other, where the miners do their own blasting.

---

3 - Section 128. Mining Laws, State of Washington 1927

4 - Section 205. Mining Laws, State of Washington 1927.

Digitized by Google

No. of mines	Kind of explosive	Blasting done by	Tonnage mined	Percentage of total tonnage	Persons employed underground
4	Permissible	Certified men	739,788	29.4	857
2	Permissible	Miners	284,444	11.2	230
Total			1,024,232	40.6	1,087

MINE SAFETY BOARD RECOMMENDATIONS ON SHOT FIRING

nformation Circular 6198, issued in November 1929, by the United States Bureau of Mines, Department of Commerce, lists recommendations of the Bureau of Mines on certain questions of mine safety, and the following recommendation is known as "Decision No. 12 relating to methods of firing shots in coal mines":

"The Bureau of Mines, Department of Commerce, extending Mine Safety Decision No. 2, recommends that for blasting either coal or rock in coal mines, permissible explosives or equivalent permissible device be used exclusively, and in addition recommends that in blasting,

"1. Each charge shall be in a hole properly drilled and stemmed with incombustible material,

"2. Each shot shall be fired separately by a permissible single-shot blasting unit, using an electric detonator or igniting equivalent of a kind specified by the bureau for the particular permissible explosive or permissible blasting device,

"3. Before and following each shot in gassy and slightly gassy coal mines, examination for gas shall be made with a permissible flame safety lamp or permissible equivalent and

"4. If more than 1-1/2 per cent of inflammable gas is found, in the quantity and by the method specified in Mine Safety Decision No. 9, the place shall be considered to be in a hazardous condition and before another shot is fired the gas shall be reduced by ventilation below the percentage and quantity specified in Decision No. 9.

"5. Each shot employing explosives shall be prepared and fired by or under the immediate supervision of a man having a State certificate as a mine examiner, fire boss, or foreman, and whenever conditions permit all other men than those authorized to prepare and fire shots shall be out of the mine when shot firing with explosives is being done."

At the four mines where blasting is done by certified men the provisions of the foregoing "decision" are essentially followed at present. Thousands of dollars have been spent in rock-dusting, which is now being practiced in the rooms and all accessible parts of the mine. All shots are mined in the clear and under the strictest definition of the term no holes are "blasted off the solid." With these precautions taken there is little

Digitized by Google

likelihood an explosion being caused by blasting operations. Other mines could well follow the example set by this group of mines, and the writer believes that this should be done, not only in the interest of safety but of economy.

About 11.2 per cent of the coal is mined at mines using closed lights, and the blasting of shots is done electrically by methods that possess merit in some respects but considerable risk in others.

STATE LAW ON BLASTING

The laws[5] of the State of Washington provide that: "In all parts of a mine where explosive gas is being generated, or dust exists in such quantities as to be dangerous or liable to cause an explosion from blown-out or windy shots, there shall be employed a sufficient number of competent persons to act as shot firers, whose duty it shall be to fire all shots properly placed by the miners, and refuse to fire any shots improperly placed. No blasts in such part of a mine shall be fired by any other person than a shot firer, fire boss, or foreman. Incombustible material for tamping must be used for that purpose, and the mine foreman shall supply same at convenient places inside the mine. Under no circumstances shall coal dust or any other combustible material be used for tamping. Each shot firer shall report to the fire boss, mine foreman, or his assistant, every shot that has refused to fire, every blown-out shot, and every shot that has missed fire, and a record shall be kept of same.

"No shot firer or any other person shall fire a shot in any working place if he can detect explosive gas in the place. In dusty mines no shot shall be fired unless the place in which the shot is to be fired is thoroughly wetted or otherwise treated to prevent the existence of any dust for a distance of not less than one hundred (100) feet from the shot to be fired."

This provision of the law is strictly adhered to in so far as the employment of shot-firers is concerned and as to precautions taken by shot-firers where fuse and "caps" are used, but in some instances the erroneous impression seems to exist that the precautions in the above quoted sections of the law are not necessary if blasting is done electrically when using a permissible type of explosive.

BLASTING PRACTICE

The procedure is as follows:

From one to seven holes are blasted to the round, but only one shot is fired at one time; blasting is done twice each day. Before blasting, a shot firer inspects the places for gas, after which the miners proceed to load, tamp, and fire their holes electrically, one shot at a time. As much as one hour might elapse from the time of the inspection until blasting is done. At another mine the mine is examined in the morning, and there

5 - Sections 116 and 117, Mining Laws, State of Washington, 1927.

Digitized by Google

is no definite rule that the place be examined again before blasting time, unless explosive gas has been found with a safety lamp.

Some mining men have the erroneous impression that it is not only safe to fire shots with gas present so long as a permissible explosive is used, especially when blasting is done electrically, but they also will argue that if this is not the case they may just as well use some other explosive that they think can do better work. When explosive gas is present, blasting with any kind of explosive is likely to be dangerous.

For the purpose of detonating the explosive, electric detonators are used with legs short-circuited. This is good safety practice, but the practice of using dry cells or any type of cell with live exposed terminals is not safe; there is danger from wires coming in contact with the live terminals[6] and also from accidental ignition of methane due to electric arc.

The reason for firing one shot at a time is that all shots but one are likely to be dependent shots, and the opening shot is fired first. It has been stated that if the opening shot fails to "pull" the other shots would not be fired; however, this practice is dangerous, as miners have failed in many instances to observe this rule.

The danger is increased when more than one shot is fired at one time by the miner. If gas were present when the first shot was fired electrically, the gas might not be ignited, while if fuse were used, the gas probably would be ignited. The first shot stirs up dust and may liberate gas, hence when the miner fires the second shot or succeeding shots without an examination for gas, an explosion may result due to ignition of gas or dust by arcs from the tangled wires.

In the instances described several very dangerous situations are possible. In any gassy mine miners should not load, tamp, and fire their own shots either electrically or otherwise.

PRECAUTIONS IN ELECTRIC BLASTING

Electric blasting possesses many advantages, but its use also introduces some hazards. When electric blasting is introduced at any mine, the following precautions should be taken.[7]

1. Electric detonators having copper, not iron, leg wires should be used.
2. Men should wait at least 30 minutes before returning to a misfire.
3. As a precaution against premature firing by stray or other electric current

6 - Howell, S. P., Experience with electrical and other means of firing shots of explosives in the anthracite region of Pennsylvania: Bureau of Mines Serial No. 2986.

7 - Recommendations by S. P. Howell, explosives engineer, U. S. Bureau of Mines.

Digitized by Google

electric detonators should have their leg wires electrically short-circuited by twisting, or otherwise, and this short circuit should be maintained until ready to connect it to the shot-firing cable.

4. The shot-firing cable should be electrically short-circuited, at the end farther from the blast, at all times except when it is to be connected to the blasting device.

5. The shot-firing cable should be tested just before connecting it to the leg wires of the electric detonator as an assurance that there is no current on the cable. The bared ends of the cable should be touched together observing whether an arc or spark is seen. If no arc or spark is seen, the bared ends of the wires should be touched to the end of the tongue; if there is a salty taste it is probable that a low voltage current is in the shooting cables.

6. The blasting cable should be sturdy, pliable, of rubber insulation, not less than 18 gage, and of adequate length.

7. In wet or very wet holes waterproof electric detonators only should be employed as the means for firing the charge.

8. Wires should not be pulled out of electric detonators.

9. Shot-firing units should be in first-class condition.

10. Manually operated magneto or electric generators should be exclusively used for firing shots. Storage batteries or dry cells having live exposed terminals should never be used.

11. The shot-firing unit should be disconnected immediately after firing a shot and immediately after a misfire.

12. Electric detonators, explosive and shot-firing cable should be kept away from live wires.

13. The instant of firing should be under definite control. In other words, always fire electrically and do not use delay action detonators in coal mine blasting.

Digitized by Google